Daily Oviposition Activities of Two Pierid Butterflies Inhabiting Sympatrically in Northern Japan

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Synopsis : Daily patterns of oviposition activities differ between two sympatric pierid species, *Pieris rapae crucivora* and *P. napi nesis*. The former has a peak of oviposition activities in the morning, the latter in early afternoon.

There have been published many papers reporting relations between daily flight activities of butterflies and climatic factors (HIROSE, 1954 ; AKIYAMA et al., 1969 ; TSUBUKI et al., 1975 ; AKITA, 1979, 1981 ; IKEJIRI et al., 1980 ; OZONE et al., 1982) with emphasis of effects of sunlight intensity and air temperature on the activities. On the other hand, effects of climatic factors on other activities of butterflies, resting, feeding, oviposition, etc., have been known in few papers. The relation of oviposition activities with climatic factors is particularly important from the viewpoint of pest control. The present study was carried out to clarify this relation in *Pieris rapae crucivora* BOISDUVAL (henceforth abbreviated as *Prc*) in comparison with that in *P. napi nesis* FRUHSTORFER (=*Pnn*), which has recently established a partial sympatry with *Prc* in openlands of northern Japan (cf. YAMAMOTO, 1983).

Before going further, I wish to express my sincere thanks to Dr. Sôichi YAMANE, the Faculty of Education, Ibaraki University, for his critical reading of the manuscript.

Materials and Methods

Oviposition activities were observed for 28 days for 12 *Prc* females (6 days for 3 females of the post-hibernating generation=G_h, 11 days for 6 ones of the first generation=G_1, and 11 days for 3 ones of the second generation=G_2) and 8 days for a *Pnn* female of G_1. Activities of the butterflies were continuously traced every day from the start of their activities in the morning to the cease in the evening on the campus of Hokkaido University between mid May and late August for *Prc* and in mid June for *Pnn* in 1976 (Table 1). Air temperature was recorded every hour during the observations. The maximum air temperature, sunlight intensity (cal/cm^2/h), and sunshine durations (h) were cited from the records taken at Sapporo Regional Meteorological Observatory.

Results and Discussion

1. *Relation between daily oviposition activities and climatic factors*

Figs. 1 and 2 show the relations of the number of eggs hourly laid (oviposition rate) by two females, G_2 47 (*Prc*) and G_1 09 (*Pnn*), together with air temperature and sunlight

Table 1 Observation data for 13 females from May to August in 1976.

Prc : *Pieris rapae crucivora*, *Pnn* : *P. napi nesis*, G_h : post-hibernating generation, G_1 : 1st generation, G_2 : 2nd generation, C : Copulation, D : Death, E : Emergence, G : Emigration, I : Inactive, M : Marking, O : 1st oviposition.

Individual code	Date		Active time	Sunshine duration (h)	Max. air temperature (℃)	Note
Prc						
G_h-13	May	11				C, M
		13	0900～1450	9.8	19.2	O
		14	0930～1500	8.7	18.6	I
		15	0600～1530	11.9	25.0	G at 1600
G_h-20	May	26				C, M
		27	0900～1130	11.5	22.9	G at 1125
	Jun.	2	0930～1010	7.7	19.0	O
		7	1115～1600	12.8	23.8	
		8	0530～1530	10.2	22.8	
		9	0900～1500	1.9	20.2	
		10	0700～1500	4.2	15.0	I
		11	0900～1630	0.0	18.0	D at 1630
G_h-23	May	28				C, M
		29	0850～1300	13.0	18.6	O, G at 1400
G_1-03	Jun.	24				E, M
		25	0730～1702	11.2	24.8	C
		26	0800～1407	4.2	23.0	O, G at 1407
G_1-05	Jun.	29				E, M
	Jul.	1	0600～1600			C
		2	0530～1600	13.3	22.4	O
		3	0530～1330	13.2	21.2	M at 1330
G_1-10	Jul.	6				E
		7	0845～1700	8.0	25.8	C, M, O
		8	0830～1300	8.0	23.8	G at 1300
G_1-17	Jul.	12	0925～1500			C, M
		13	0730～1700	9.0	25.0	O
		14	1000～1530	4.7	25.4	
		15	1000～1330	0.4	19.7	I
		16	0700～1000	4.4	20.9	G at 1000
		17	1200～1340	7.7	19.3	Rediscovered
		18	0700～0950	10.0	21.1	G at 0950
G_1-22	Jul.	17				C, M
		19	0630～1130	12.7	22.8	O, G at 1130
G_1-23	Jul.	17				C, M
		23	0700～1720	7.9	31.9	
		24	0600～0800	11.7	33.4	G at 0800
G_2-26	Jul.	27				E, M
		29	0800～1800			C
		30	0600～1730	8.2	27.2	O
		31	0630～0700	0.8	28.0	G at 0700
G_2-41	Aug.	6				E, C, M

Table 1 (Continued)

Individual code	Date		Active time	Sunshine duration (h)	Max. air temperature (℃)	Note
		7	0700～1700	8.9	24.7	O
		9	0830～1340	5.5	24.8	G at 1340
G_2-47	Aug.	8				C, M
		17	0900～1700	10.6	24.2	
		18	0640～1600	10.1	24.2	
		19	0650～1700	8.3	27.5	
		20	0700～1700	2.8	23.4	
		21	0730～1200	3.6	23.8	
		22	0830～1000	5.0	21.6	I
		23		2.7	22.0	I
		24	0830～1600	8.4	22.1	
		25	0700～1600	7.4	21.1	
		26	0630～1100	11.4	25.6	D
Pnn						
G_1-09	Jun.	12				E, M
		15				C
		16	1050～1600	7.9	18.0	O
		17	0940～1300	6.6	17.8	
		18	0630～1700	11.8	19.8	
		19	0600～1500	9.9	21,2	
		20	0605～1510	11.5	25.0	
		21	0800～1700	10.0	22.3	
		22	0730～1210	5.2	18.5	
		23	1000～1400	4.6	19.2	G at 1400

intensity. In *Prc* the oviposition rate increased with a rise of air temperature and sunlight intensity, showing a peak before noon, at which the sunlight intensity attained maximum. After then, it suddenly dropped, or sometimes stopped completely, even though the two factors were still available enough for the oviposition (Fig. 1, A–B). In *Pnn*, however, ovipositions were frequently seen also in the descending phase of these factors in the afternoon (- - →) as well as the ascending phase in the morning (——→). The peak of oviposition rate of this species was mostly seen when the light intensity was highest (Fig. 2, A–C, E–H).

Table 2 shows means and ranges of air temperature and light intensity under which the start, peak, and end of oviposition activities were observed. In *Prc* ovipositions were made in the condition of air temperature ranging from 16.0 to 33.0 ℃, and of light intensity ranging from 20 to 75 cal/cm^2/h. With the advance of seasons air temperatures at the time of the start, peak, and end of oviposition activities were higher, while the light intensity lower (Table 2, Fig. 3). In *Pnn* ovipositions were observed in the range of 16.5～23.7 ℃ in temperature and 30～75 cal/cm^2/h in light intensity. Females of *Pnn* (G_1) laid eggs at lower air temperature and higher light intensities than did *Prc* females of G_1. These two climatic factors seem to act antagonistically for the oviposition activities as for the case of flight

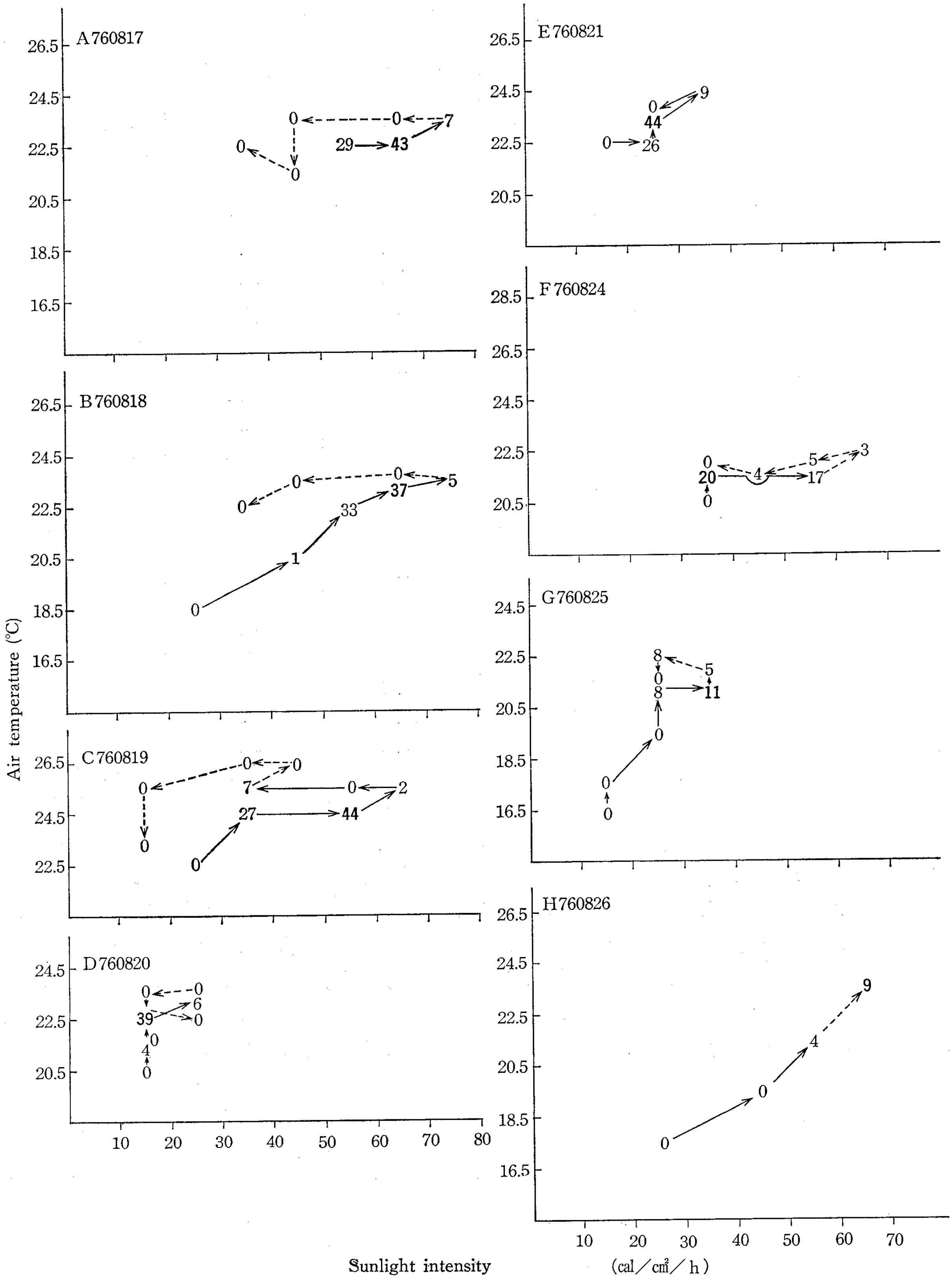

Figure 1 Daily changes of the number of eggs laid by *Pieris rapae crucivora* for 8 days from August 17～26 in 1976, shown in bidimensional spaces of air temperature and sunlight intensity. An arrow is equivalent to an hourly interval. ⟶ : in the morning, - - → : in the afternoon.

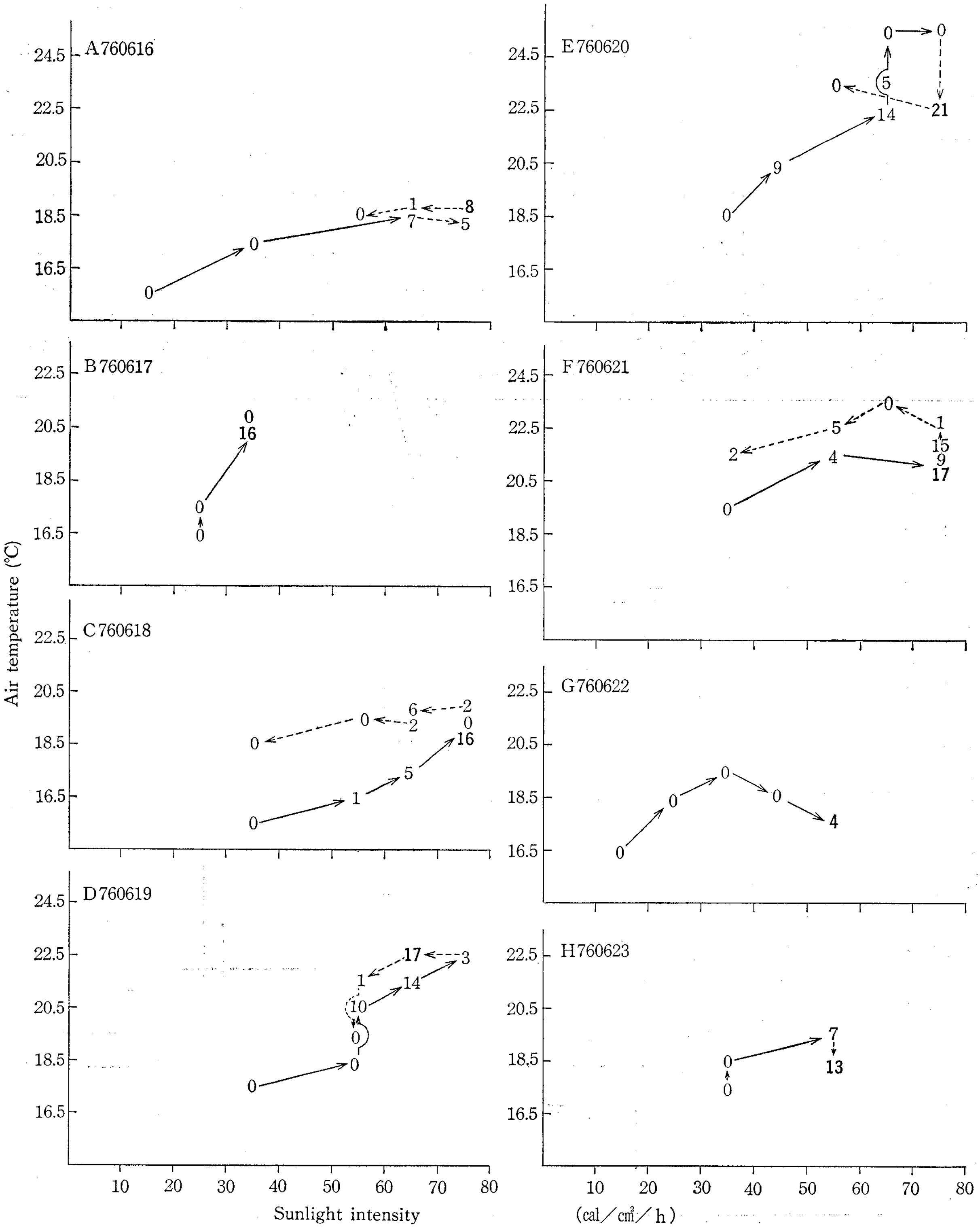

Figure 2 Daily changes of the number of eggs laid by *Pieris napi nesis* for 8 days from June 16～23 in 1976, shown in relation to air temperature and sunlight intensity. An arrow is equivalent to an hourly interval. ——→ : in the morning, - - → : in the afternoon.

Table 2 Mean±S. D. (range) of air temperature (upper, ℃) and light intensity (lower, cal/cm²/h) at the time of the start, peak, and end of oviposition activities in two pierid species.

Prc : *Pieris rapae crucivora*, *Pnn* : *P. napi nesis*, G_h : post-hibernating generation, G_1 : 1st generation, G_2 : 2nd generation.

	Start	Peak	End
Prc-G_h	18.7± 2.4 (16.0～22.5) / 53.5±15.6 (29.0～74.0)	18.7± 2.4 (16.0～22.5) / 53.5±15.6 (29.0～74.0)	21.5± 2.5 (18.0～24.1) / 51.4±14.8 (29.0～81.0)
Prc-G_1	21.8± 3.6 (17.9～29.1) / 40.6±15.9 (20.0～71.0)	21.9± 3.2 (18.0～29.1) / 45.2±16.5 (20.0～71.0)	23.1± 4.7 (18.0～33.0) / 44.4±13.9 (20.0～66.0)
Prc-G_2	22.3± 1.2 (20.3～24.0) / 36.0±12.9 (15.0～57.0)	23.4± 1.6 (21.0～24.9) / 43.2±17.6 (17.0～67.0)	23.9± 1.7 (21.7～27.2) / 41.0±17.9 (21.0～74.0)
Pnn-G_1	19.2± 1.5 (16.5～21.1) / 51.6±10.7 (30.0～68.0)	20.2± 2.0 (17.7～22.9) / 61.9±15.6 (30.0～75.0)	20.2± 2.1 (17.9～23.7) / 53.5±13.4 (30.0～67.0)

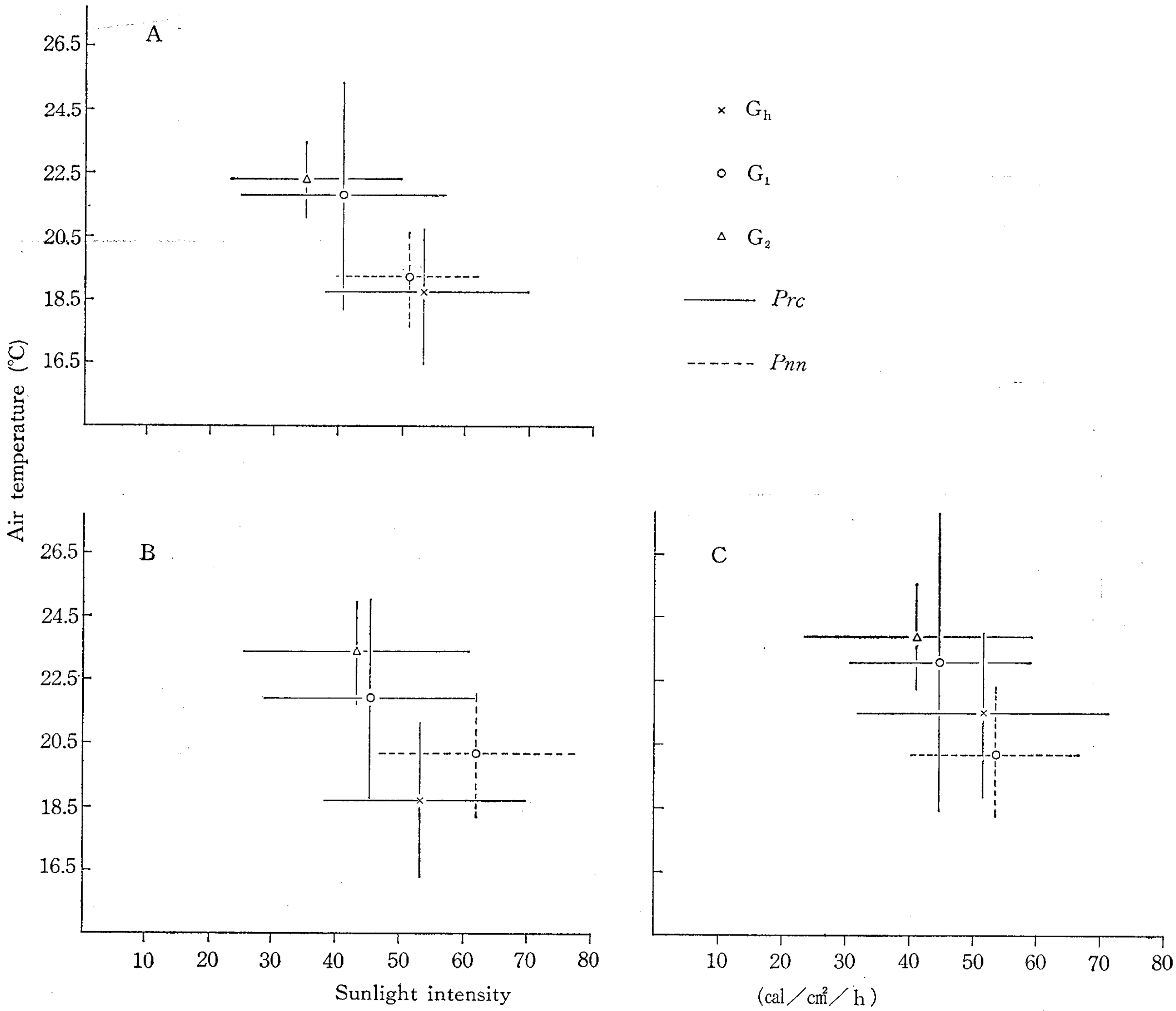

Figure 3 Seasonal changes of the climatic factors (air temperature and sunlight intensity) at the start (A), peak (B), and end (C) of oviposition activities of *Pieris rapae crucivora* (*Prc*) and *P. napi nesis* (*Pnn*).
G_h=post-hibernating generation, G_1=1st generation, G_2=2nd generation.

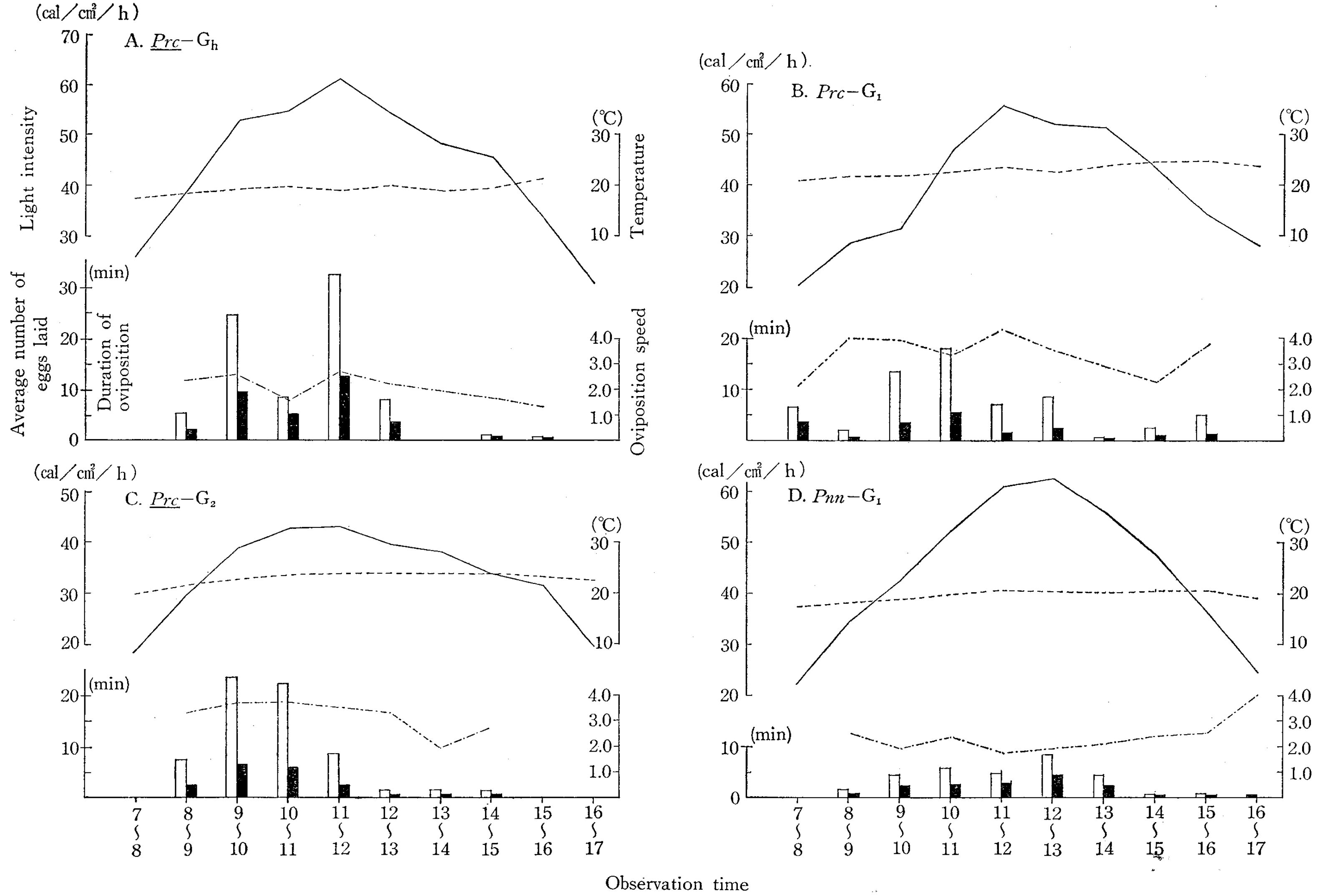

Figure 4 Daily changes of the average number of eggs laid per hour (=a, □) for three generations (G_h=post-hibernating generation, G_1=1st generation, G_2=2nd generation), together with changes of the average duration of oviposition (=b, ■), oviposition speed (a/b, -·-·-), and two climatic factors (air temperature, - - - -, and sunlight intensity, ——). *Prc*= *Pieris rapae crucivora*, *Pnn*= *P. napi nesis.*

activities (HIROSE, 1954). These seasonal and interspecific differences in the conditions for oviposition activities would result in (or from) seasonal and interspecific differences of daily patterns of oviposition activities.

2. *Seasonal and interspecific differences of daily patterns of oviposition activities*

A seasonal difference of daily patterns of oviposition is briefly described here, though observations were limited to *Prc.* Fig. 4 shows daily changes of the average number of eggs laid per hour (the average oviposition rate=a) for each generation, separately, together with the duration for oviposition (min) (=b), oviposition speed (=a/b), and the two climatic factors. The peak of oviposition activities of *Prc* shifted seasonally to earlier time from 11 : 00~12 : 00 for G_h (Fig. 4A) through 10 : 00~11 : 00 for G_1 (Fig. 4B) to 9 : 00~10 : 00 for G_2 (Fig. 4C), in parallel with an increase of the average air temperature.

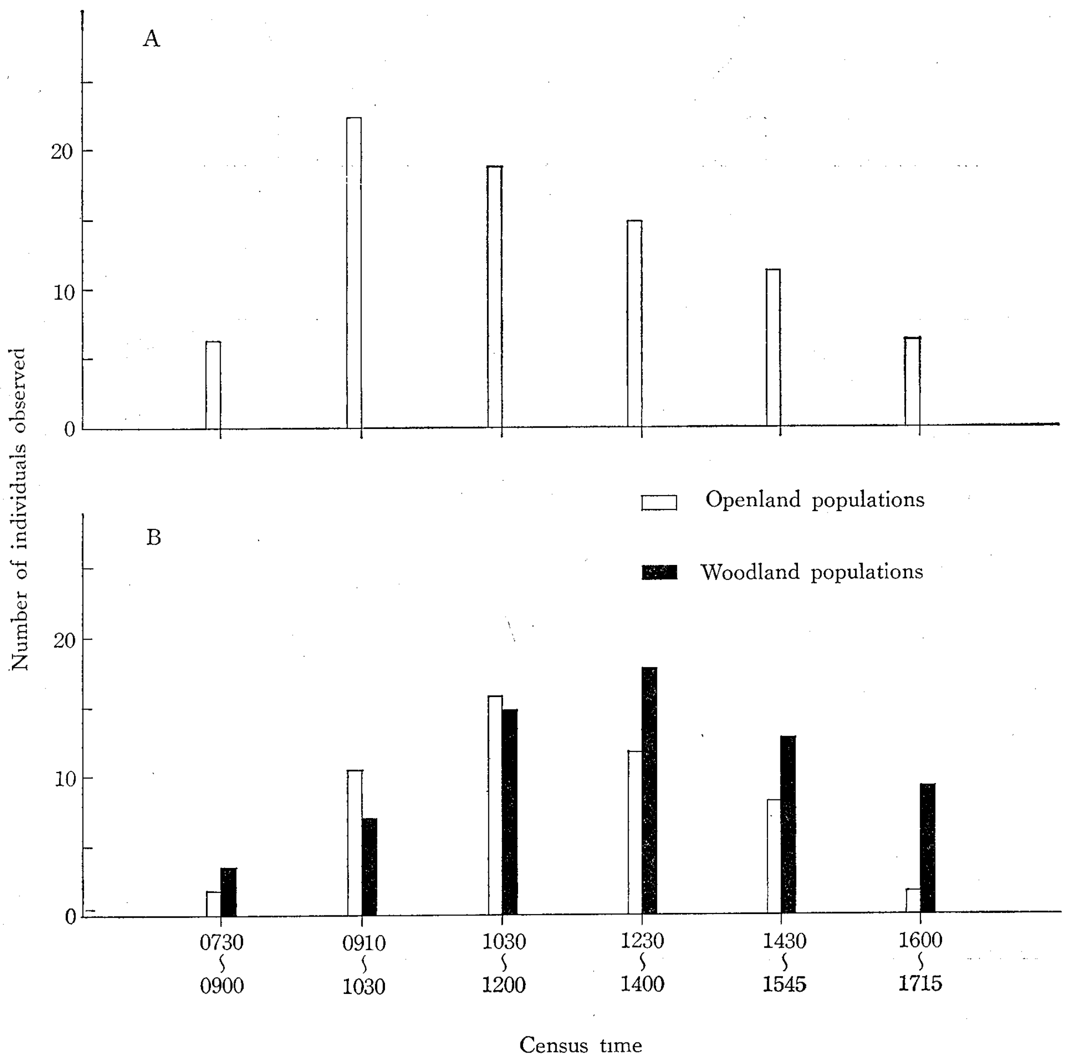

Figure 5 Daily changes of flight activities of two species observed by the belt transect censuses carried out six times per day at Jozankei from May to October in 1973. A : *Pieris rapae crucivora,* B : *P. napi nesis.*

The daily pattern of oviposition differed between the two species (*Prc* : Fig. 4B, *Pnn* : Fig. 4D). The average oviposition rate of *Prc* showed a unimodal pattern with a morning peak, while that of *Pnn* with an afternoon peak, being both parallel with the daily pattern of the duration of oviposition. Furthermore, the daily pattern of the oviposition speed differed between the two species ; in *Prc* the speed was larger in the morning than in the afternoon, while in *Pnn* low even in the morning as well as in the afternoon. The average oviposition rate of *Prc* seems to be positively affected both by the duration of oviposition and by the oviposition speed, while that of *Pnn* only by the duration of oviposition. In conclusion it was clear that these two pierid species, living sympatrically and utilizing the same oviposition plant in openlands, use their oviposition resources at different time.

3. *Relations between oviposition and flight activities*

Prc is an openland species, and prefers sunny conditions. The time of its oviposition peak and the flight activity peak were both observed in the morning, though flight activities continued till the afternoon (Fig. 5A). On the other hand, *Pnn* is a eurytopic species, consisting of openland and woodland populations. The former populations probably derived from the latter ones (cf. YAMAMOTO, 1983). According to previous observations (cf. YAMAMOTO, 1975), the former populations showed a morning peak of flight activities, and the latter an afternoon peak (Fig. 5B). The *Pnn* population observed in this survey belongs to an openland population with a morning peak of flight activities and an afternoon peak of oviposition activities, though woodland populations probably have peaks of these two activities at the same time in the afternoon. The discrepancy of the time of the peak in *Pnn* openland population between the two activities may be caused by a thermal difference of microhabitats at which the two activities are released ; both shaded areas (for oviposition) and sunny ones (for nectar intake) are requisites of *Pnn* (OHSAKI, 1983), and sunny conditions in openlands would cause an earlier release of activities except for oviposition. This inference also elucidates a cause of interspecific difference of daily oviposition activity patterns.

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摘　　要

札幌周辺域で，キレハイヌガラシ（*Rorippa sylvestris*）を共通の食草とする同所性モンシロチョウ属の2種，モンシロチョウとエゾスジグロシロチョウとは，産卵時間帯にずれを生じている．モンシロチョウの産卵は，午前中に多く観察され，エゾスジグロシロチョウは，午後に集中的に産卵した．この産卵時間帯の違いは，両種の産卵場所に対する選好性の違いに原因があるようであった．